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SOURCES OF THE FLAVOR IN BUTTER

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THE SOURCES OF THE FLAVOR IN BUTTER

By B. W. Hammer

Flavor is one of the important points considered in determining the quality of butter. The sources of this flavor and the exact way in which it is developed are questions which have long been of weight with investigators interested in dairying. The experiments herein reported were carried out with the idea of applying to these problems some of the information recently secured in a study of starters.

HISTORICAL

Conn[1], in his extensive studies on the ripening of cream, early (1889) concluded that "while the ripening of cream is undoubtedly dependent upon the presence of bacteria, it is doubtful whether one species can produce what is known as ripened cream." Later (1890) he[2] specifically pointed out that in cream ripening something besides souring takes place and that "while the addition of acid does certainly hasten the souring, it does not accomplish the other purposes of ripening, for the whole process is a complicated one connected with bacterial growth, and the formation of acid is only a part of it." In his[3] study of the effect of various organisms on the flavor of butter, Conn found (1893) that no single species produced a typical ripening of the cream or the usually expected flavor in the butter and that the few acid-producing species tried did not have as good an influence on the butter as the alkali-producing species. Conn[4] (1896) also pointed out that acid and flavor should be distinguished and that while acid is developed from the sugar, the flavor probably comes from other sources; he also considered that aroma should be separated from flavor and stated that it is more unusual for an organism to produce aroma than flavor.

The work done by Hammer and Bailey[5], Storch[6], and Boekhout and Ott de Vries[7] has shown that organisms other than *Streptococcus lacticus* are present in starters and play an important part in the aroma and flavor development. Hammer[8]

[1]Conn, H. W. Bacteria in Milk, Cream and Butter. 2nd An. Rpt. Storrs Agr. Expt. Sta. 1889.

[2]Conn, H. W. Ripening of Cream. 3rd An. Rpt. Storrs Agr. Expt. Sta. 1890.

[3]Conn, H. W. Bacteria in the Dairy. 6th An. Rpt. Storrs Agr. Expt. Sta. 1893.

[4]Conn, H. W. Bacteria in the Dairy. 9th An. Rpt. Storrs Agr. Expt. Sta. 1896.

[5]Hammer, B. W., and Bailey, D. E. The Volatile Acid Production of Starters and of Organisms Isolated from Them. Res. Bul. Ia. Agr. Expt. Sta. 55. 1919.

[6]Storch, V. Fortsatte Undersogelser over Fremstillingen af Syrevaekkere. 102de Beretning fra Forsogslaboratoriet, 1919.

[7]Boekhout, F. W. J., and Ott de Vries, J. J. Aromabildner bei der Rahmsauerung. Centbl. f. Bakt. Abt. 2, 49: 373, 1919.

[8]Hammer, B. W. Volatile Acid Production of *S. Lacticus* and the Organisms associated with it in Starters. Res. Bul. Ia. Agr. Expt. Sta. 63. 1920.

found two types of these organisms, which he has named *Streptococcus citrovorus* and *Streptococcus paracitrovorus,* in the starters studied by him and has shown that they produce volatile acid from citric acid; in the case of *S. citrovorus,* which causes very little increase in the acidity of milk, the lactic acid produced by *S. lacticus* also apparently yields volatile acid, while with *S. paracitrovorus* volatile acid probably comes from the lactic acid produced either by this organism or by *S. lacticus.* It seems very probable that the volatile acid must be important from the standpoint of the aroma and flavor development in butter.

RESULTS SECURED

In the trials carried out an attempt was made to produce flavor and aroma in butter by the use, in pasteurized cream, of *S. citrovorus* or *S. paracitrovorus* as the only organism. In order to increase the volatile acid production of this organism sterile citric or lactic acid was usually added.

The early experiments were carried out with very small lots of cream. Two-quart jars of the kind used in canning were employed and the cream pasteurized in these by standing the jars in hot water; the cream was then cooled, inoculated, and finally churned by putting the jars in a shaking machine. The butter was washed in the jars and then removed to open dishes where it was worked and salted. After making, the butter was held for from 1 to 3 days and then scored by an experienced butter judge, who was given no information as to how the different lots of butter were made. Tables I to VI, inclusive, give a portion of the results secured.

In the trials reported in table I the addition of *S. citrovorus* and sterile citric or lactic acid to the cream resulted in a significant increase in the score of the butter, and the increase was greater with 0.2 percent citric acid than with 0.1 percent; *S. citrovorus,* without added acid, gave a slight increase over the check. Table II shows that essentially the same results were secured with *S. paracitrovorus* as with *S. citrovorus.* The data given in table III show the same results as those given in table I; the increase in score when *S. citrovorus* and sterile citric acid were added was closely related to the amount of acid employed.

TABLE I—BUTTER MADE WITH *S. CITROVORUS*

Cream past. and inoc. 8/26; churned 8/27; ripened at 21° C. for approximately 20 hours

	Score 8/28
Check—cream past. but no additions made	92.5
Cream+*S. citrovorus*	93.0
Cream+*S. citrovorus*+approximately .1% citric acid	94.0
Cream+*S. citrovorus*+approximately .2% citric acid	94.5
Cream+*S. citrovorus*+approximately .2% lactic acid	94.5

TABLE II—BUTTER MADE WITH *S. PARACITROVORUS*

Cream past. and inoc. 8/30; churned 8/31; ripened at 21° C. for approximately 20 hours

	Score 9/1	Organisms per cc. at time of churning, plate method
Check—cream past. but no additions made	92.5	1,800,000
Cream+*S. paracitrovorus*	93.5	168,000,000
Cream+*S. paracitrovorus*+approximately .1% citric acid	94.0	162,000,000
Cream+*S. paracitrovorus*+approximately .2% citric acid	95.0	120,000,000
Cream+S. *paracitrovorus*+approximately .2% lactic acid	94.5	220,000,000

Table IV presents results secured with *S. lacticus* in addition to those obtained with *S. citrovorus*. *S. lacticus* gave a better flavor and aroma when sterile citric acid was added than when no acid was employed, but in neither case was the flavor and aroma as good as that produced by *S. citrovorus* in the presence of added citric acid; the addition of sterile citric acid without any inoculation gave a higher score than when *S. lacticus* was employed without adding this acid.

The results given in table V are much like those given in table IV altho the cream in which *S. lacticus* was grown gave a higher scoring butter than the uninoculated cream to which sterile citric acid was added. The presence of a check in the lot shows that all of the additions tried gave a higher scoring butter than where nothing was added to the cream. In the results presented in table VI an increase in the time of incubation increased the score when sterile citric acid was added along with *S. citrovorus*, but decreased the score when sterile lactic acid was used; however none of the butter made in these trials was very satisfactory.

In tables II and III the number of organisms as determined by the plate method are given. These data show that the addition of *S. citrovorus* or *S. paracitrovorus* very evidently resulted in considerable growth; the actual number of organisms,

TABLE III—BUTTER MADE WITH *S. CITROVORUS*

Cream past. and inoc. 9/1; churned 9/2; ripened at 21° C. for approximately 20 hours

	Score 9/3	Organisms per cc. at time of churning, plate method
Check—cream past. but no additions made	92.5	5,150,000
Cream+*S. citrovorus*	93.0	46,000,000
Cream+*S. citrovorus*+approximately .1% citric acid	93.25	38,000,000
Cream+*S. citrovorus*+approximately .15% citric acid	94.0	44,500,000
Cream+*S. citrovorus*+approximately .2% citric acid	94.5	46,000,000
Cream+*S. citrovorus*+approximately .2% lactic acid	93.25	54,000,000

TABLE IV—BUTTER MADE WITH *S. LACTICUS* OR *S. CITROVORUS*

Cream past. and inoc. 9/13; churned 9/14 and 9/15; ripened at 21° C.

	Approximate ripening time	Score 9/16
Cream+*S. lacticus*	20 hr.	93.0
Cream+*S. lacticus*+.2% citric acid	20 hr.	93.5
Cream+citric acid—no inoc.	20 hr.	93.25
Cream+*S. citrovorus*+.2% citric acid	20 hr.	93.75
Cream+*S. citrovorus*+.2% citric acid	48 hr.	94.0

however, must have been much greater than the results presented indicate, because the organisms grow in chains and these could not be broken up by the agitation given. The data secured show also that the uninoculated cream when held at 21° C. for approximately 20 hours after efficient pasteurization, had considerable numbers of organisms present.

The results presented in tables I to VI indicate that *S. citrovorus* is important in the production of flavor in butter. It seemed desirable, however, to see what butter made by adding *S. citrovorus* and sterile citric acid to pasteurized sweet cream would score when compared with butter made by the usual methods. Accordingly three churnings of butter were prepared, using from 10 to 20 gallons of cream for each churning, and the butter sent to the scoring contest held in connection with the Iowa Buttermakers' Convention (November, 1920). The three tubs of butter were scattered among the other entries and the judges (three) were given no information concerning them.

Table VII shows the data secured in connection with the three churnings and the scores given. Each tub scored 94.0 or better at an age varying from five to ten days. In the two lots of cream on which plate counts were run, the results secured agree in general with those given in tables II and III; as already pointed out these values are undoubtedly much too low since the chains of organisms are very difficult to break up. The three tubs of butter were among the high nine of the 103 entries, but a number of tubs scored higher than any of the three.

A fourth tub of butter sent to the convention was made by adding a culture of *S. citrovorus* and 0.08 percent citric acid to 15 gallons of cream and then after seven hours a culture of *S. lacticus;* the cream was held at 21° C. thruout the ripening and was cooled 16 hours after the *S. lacticus* culture was added. At the time of churning the bacterial count by the plate method

TABLE V—BUTTER MADE WITH *S. LACTICUS* OR *S. CITROVORUS*

Cream past. and inoc. 9/20; churned 9/21; ripened at 21° C. for approximately 20 hours

	Score 9/22
Check—cream past, but no additions made	92.0
Cream+*S. lacticus*	93.0
Cream+*S. lacticus*+.2% citric acid	93.25
Cream+.2% citric acid—no inoc.	92.5
Cream+*S. citrovorus* (No. 10)+.2% citric acid	94.0
Cream+*S. citrovorus* (No. 11)+.2% citric acid	93.5

TABLE VI—BUTTER MADE WITH *S. CITROVORUS*

Cream past. and inoc. 9/28; churned 9/29 and 9/30; ripened at 21° C.

	Approximate ripening time	Score 10/2
Cream+*S. citrovorus*+.2% citric acid	24 hr.	92.75
Cream+*S. citrovorus*+.2% citric acid	48 hr.	93.5
Cream+*S. citrovorus*+.2% lactic acid	24 hr.	93.0
Cream+*S. citrovorus*+.2% lactic acid	48 hr.	92.0

was 58,000,000 per cc. The butter scored 92.5 at an age of three days.

The results presented show that with added citric or lactic acid either *S. citrovorus* or *S. paracitrovorus* is capable of bringing about a fermentation in sweet cream that results in a desirable flavor and aroma in the butter. Since one (and occasionally both) of these organisms is always present in a good starter, it seems very probable that they must be of importance in the production of flavor and aroma in butter when a starter is used in the manufacture. *S. lacticus* in all probability has a part in the production of the aroma and flavor producing substances but it seems that the organisms associated with *S. lacticus* in starters are the really important ones in this connection.

The use of pure cultures of *S. citrovorus* or *S. paracitrovorus* together with either citric or lactic acid cannot be expected to yield butter of a better flavor and aroma than when good starters are used. The proper balance in starters between *S. lacticus* and the organisms associated with it apparently results in the elaboration of products that are excellent for the production of flavor and aroma in butter. Moreover, the pronounced acid development by *S. lacticus* apparently tends to prevent the growth of undesirable bacteria that are present in cream even when it has been carefully pasteurized while the products of *S. citrovorus* or *S. paracitrovorus* probably have no such effect. This seems to be sufficient reason for believing that it will be much more difficult to control the fermentation when pure cultures of the latter organisms are used, than when starters are employed.

There is one angle to the use of pure cultures of *S. citrovorus* or *S. paracitrovorus,* however, that suggests interesting possibilities. Since a high acidity in cream probably favors deterioration in the butter made from it, the use of pure cultures, which give a good flavor and aroma without any considerable acid

TABLE VII—BUTTER MADE WITH *S. CITROVORUS*

	Lot A	Lot B	Lot C
Amount of cream	10 gal.	10 gal.	20 gal.
Approximate time of ripening	20 hr.	20 hr.	20 hr.
Percent citric acid added	.2 pct.	.2 pct.	.1 pct.
Age at time of scoring	10 days	9 days	5 days
Organisms per cc. at time of churning, plate method	26,200,000	122,000,000	
Score given at Iowa Buttermakers' Convention	94.25	94.0	94.0

development, may result in the production of butter with exceptional keeping qualities. If butter could be produced with a high flavor and aroma and with keeping qualities such as are possessed by sweet cream butter the procedure would be well worth while. The dairy section of the Iowa Agricultural Experiment Station is at present studying the keeping quality of butter made by inoculating cream with pure cultures of *S. citrovorus*.